Winter 1988

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NSU Oceanographic Center

Nova University Oceanographic Center

Currents

Winter 1988 Volume II Number 1

UPWELLING AND DOWNWELLING IN THE ARABIAN SEA

Dr. Gary Hitchcock has cruised the Arabian Sea twice in the past year: from Muscat, Oman to Mombasa, Kenya during December-January, 1986-87, and from Mombasa to Muscat during July-August, 1987. Ph.D. student **Denis Frazel** accompanied him on the summer cruise. Their work was sponsored by the Office of Naval Research and was closely coordinated with Chief Scientist **Dr. Donald Olson**, of the University of Miami.

Emphasis was on physical oceanographic measurements, but some biology was involved, primarily because of an instrument that Hitchcock and **Dr. Thomas Rossby** developed at the University of Rhode Island. The instrument, the IFF fluorometer, drifts on predetermined density surfaces and provides a direct measurement of upwelling or downwelling rates, depending on which monsoon is being studied.

The northeast monsoon, which occurs in the Indian Ocean during the winter, causes downwelling to occur; the summer southwest monsoon brings on a period of upwelling. For the uninitiated, during upwelling, nutrients are brought up into the euphotic zone (the upper illuminated layer), allowing plants to photosynthesize. During downwelling periods, lower nutrient conditions are present and the plant biomass is reduced. Consequently, fewer animals are found within the upper mixed layer.

Getting back to the instrument: the objective of the float is to provide direct measurement of vertical water motion and concurrent measurement of the phytoplankton biomass.

Hitchcock and Frazel also mapped the productivity of the plankton biomass of the northern Arabian Sea. Their observations are being combined with data on freon gas distribution, currents, and oxygen in an attempt to explain the occurrence of a deep oxygen minimum in the Arabian Sea. According to Hitchcock, there is a water layer of several hundred meters thickness where there is nearly undetectable dissolved oxygen. Both biologists and physical oceanographers are interested in this layer, because tracer studies have shown that the oxygen minimum has been in contact with the surface fairly recently (several years; from **Dr. Rana Fine**, University of Miami). Thus the low oxygen concentrations must be the result of plankton that has sunk from the overlying euphotic zone and decomposed, indicating that this is not an isolated body of internal water.

What all of this boils down to is that when a monsoon occurs, productivity in overlying waters is fairly high. When the monsoon

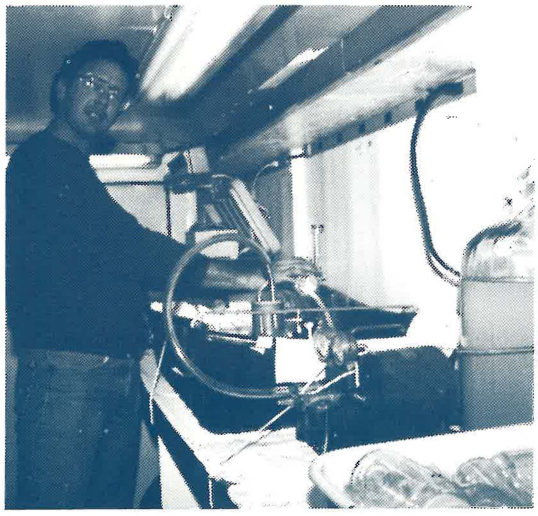
Dr. Gary Hitchcock uses acoustic recorder at sea.

PRIMARY PRODUCERS PROBED

Ph.D. candidate **Denis Frazel** is trying to determine accurately the specific growth rate of phytoplankton in the open ocean. His thesis proposal is entitled "Phytoplankton Chlorophyll *a* Carbon Specific Growth."

Working with his research professor, **Dr. Gary Hitchcock**, Frazel is utilizing a relatively new method that has not been tested in open ocean situations. The method, performed primarily at sea, involves the inoculation of water samples with radioactive ^{14}C and incubation of the samples for a given period of time. The samples are then filtered, frozen, and transported to the laboratory for subsequent analysis.

With the assistance of **Dr. Gary Kleppel**, High Performance Liquid Chromatography (HPLC) is used to identify and isolate the chlorophyll *a* from phytoplankton that is retained on the filters. The amount of radioactivity in the chlorophyll *a* (specific activity) then can be used to determine growth. Since chlorophyll *a* is found only in plants (phytoplankton), the growth determination is specific for phytoplankton.



Denis Frazel, at work in the laboratory at sea.

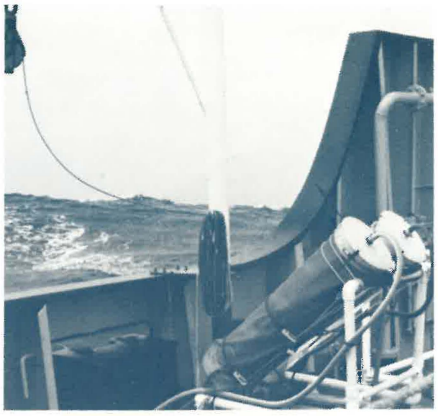
Frazel has gathered water samples from the Atlantic, Pacific, and Indian Oceans. If the method proves viable in such diverse regions, he feels that it may potentially have global application.

The significance of this study is summarized in Frazel's dissertation proposal: "A thorough knowledge of phytoplankton rate processes, including specific growth, is basic to an understanding of marine food chains. The phytoplankton, through their photosynthetic pigments, produce most of the energy used within the pelagic ecosystem. Thus, changes in phytoplankton growth rates can influence the energetics of an ecosystem."

Frazel received his M.S. in Marine Biology from Nova in 1986. His thesis examined the influence of lobster trap escape gaps on the capture and behavior of spiny lobsters, and his areas of research were confined primarily to local and Caribbean waters.

Last summer, however, Frazel had the opportunity to visit such faraway places as Kenya, Oman, and Pakistan, while participating in an Indian Ocean research cruise. The expedition was one of only a few ever to have utilized an interdisciplinary approach to an oceanographic study of the Indian Ocean. The physical, biological and chemical aspects of the region were all observed during both the winter and the summer monsoon seasons -- a unique scientific scenario.

As for the cruise itself, Frazel relished his time aboard the British research vessel *Charles Darwin*, as well as the unique opportunity that he had to collaborate with foreign scientists. Not many Ph.D. candidates can make that statement.



Deck-mounted NC2 plankton incubator on the Indian Ocean cruise.

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stops, the phytoplankton sink to intermediate levels, creating a low-oxygen layer.

Hitchcock and Frazel were able to see a bit of the East after the summer cruise. They spent a week in Karachi, Pakistan, delivering equipment and laying groundwork for a collaborative study with oceanographers at the National Institute in Karachi.

Both cruises were made aboard the British vessel R.R.S. *Charles Darwin*. Hitchcock comments that spending Christmas at sea last year "actually was an enjoyable experience. We had a 3-hour English dinner." Taking the British at their word that this would be a "dress dinner" as well, all the Americans wore coats and ties. The English, however, meant something quite different, he continues, "arriving 'dressed up' as Arabs and policemen, and in other crazy costumes." There'll always be an England.

When asked about initiation rites as he crossed the equator for the first time, Hitchcock responded with a grin: "really unique," and "an experience not to be forgotten...." End of quote. End of interview.

UNDERCURRENTS
INSTITUTE OF MARINE AND COASTAL STUDIES

Course Offerings For Spring

Spring Session, Institute for Marine and Coastal Studies: April 4 - June 24, 1988.

Marine Environmental Research Programs (OC-6130). Includes a description of current federally and privately funded marine research programs dealing with aspects of the marine environment. Instructor: **Dr. Gary Hitchcock** (Center faculty).

Marine Botany (OC-6070). Emphasizes identification and understanding of tropical marine algae, grasses, seaweeds, and mangroves. Includes several field trips and individual botanical projects. Instructor: **Dr. David DeMay** (St. Thomas of Villanova Univ.).

Marine Geology (OC-5604). A CORE course for both degree programs. Topics range from fossil reefs to mid-ocean ridge basalts. Includes geology of southeast Florida. Instructor: **Dr. Pat Blackwelder** (Center faculty).

Coastal Engineering and Protection (CZM-605). Evaluates practices of coastal and offshore engineering in terms of impact on shorelines. Study of causes of modified coastal configurations from a practical standpoint. A look at geomechanics in relation to civil, military, and industrial engineering projects. Instructor: **Dr. William Venezia** (U.S. Navy Surface Warfare Center).

SHRIMP: THE SHORT COURSE

The third in a series of short (9-day) courses in shrimp mariculture was held at the Center during the fall semester, in conjunction with Coastal Science and Engineering, Inc. (CSE), of Columbia, S. C. The course is designed to provide hands-on training in the latest methods used in commercial shrimp mariculture. The species under study this time was *Penaeus vannamei*

Dr. Bart Baca, who received his Ph.D. in algae culture from Texas A&M, is the course maestro. He provides overall management and instruction in algal culture techniques for penaeid shrimp. **Steve Hopkins**, of the Waddell Mariculture Center in S. C., has experience in hatchery design and is the primary instructor for the fall course; **Granvil Treece**, of the Texas Agricultural Extension Service, will be the primary instructor in the spring. **Raymond J. Rhodes**, an aquaculture business consultant and industry economist for the state of South Carolina, presents business management aspects of aquaculture ventures. Locally, the person in charge of the course laboratory facilities is **Carol J. Reese**, a graduate student in Ocean Science.

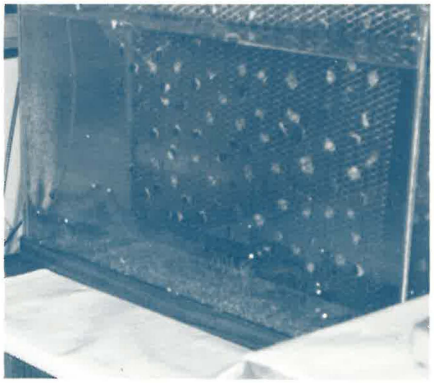
The course consists of morning lectures on every aspect of mariculture, from life history stages to hatchery design, larval food culture, larval culture techniques, stocking, diseases, breeder sourcing, maturation, and marketing and finance.

The group moves from the classroom to the laboratory, where the students strive to keep their larval shrimp alive. Fortunately for the students but unfortunately for the shrimp, the course finale is a *taste test* party.

So far this course has proved a success on an international scale. Students have included biologists from Caltech and Austria, a member of the World Bank in Maryland, shrimp project organizers from Puerto Rico and Colombia, and participants from Greece, Mexico, Uruguay, and Venezuela.

The short course will be offered again June 20-29 (*Penaeus vannamei)* and July 2-9 *(Macrobrachium rosenbergii)*. A full-term curriculum course is planned for the period July 4 - September 19, 1988.

Dr. Bart Baca prepares a home for the shrimp.



The shrimp, at home.

SPOTLIGHT

PHAGOTROPHY, PHOTOSYNTHESIS AND THE PHOTIC ENVIRONMENT

Carol J. Reese, who is working toward the M.S. degree in ocean science, has been studying the symbiotic relationship between coral polyps and marine plants. Her thesis topic is "The Use of Pigments as Indicators of a Response to an Environmental Change by Animal/Algal Symbiotic Relationship."

Marine algae, which live inside the cells of the host coral polyp, photosynthesize, as do all plants, producing nutrients that are beneficial to the coral. In return, the polyp provides the algae with a place to reside, as well as nutrients in the the form of animal waste products. Thus the symbiosis.

Algae (plants) and coral polyps (animals) contain certain distinctly different pigments. In coral polyps, animal pigments are obtained by means of phagotrophy (ingestion of particulate matter through the mouth). Reese proposes to show that there is a relationship between the quantity of plant pigment and that of animal pigment that reflects the contribution made by each nutritional mode. For example, a large quantity of animal pigment present in a polyp may indicate that a high degree of phagotrophy may have taken place, and that there has been less dependence on symbiosis.

In order to test this theory, a field survey will be conducted, with **Dr. Gary Kleppel**, to assess the naturally occurring plant and animal pigments in corals over a depth range of 0-30 meters (within the photic zone, where photosynthesis can take place). In the laboratory, pigments will be extracted from coral polyps and analyzed by means of HPLC and spectrophotometry. The study will determine whether or not phagotrophy increases the amount of animal pigment in coral polyps, and whether the amount of light in the photic environment has an influence on the amount of assimilation and/or phagotrophy that takes place.

Reese initially thought that perhaps in the not-so-clear waters of a populous area (e.g., South Florida, as opposed to the Bahamas) there might be a decrease in the photosynthate available to coral animals from algae at relatively shallow depths. If so, the polyps then might have to eat phagotrophically at shallower depths in order to maintain their energy levels. "But," she has decided, "it is more involved than that. Water temperature, salinity and other physical factors, plus the amount of available particulate food, combine to change the pigment composition of the coral polyp."

Through this study Reese hopes to learn the effects of water temperature, as well as man-made perturbations, on coral animals. Any new findings in this study area are bound to aid in the difficult task of coral reef assessment.

Reese feels that no doubt other symbiotic relationships exist that are influenced by the photic environment, even in the open ocean. Her next goal is to undertake new pigment studies, en route to the Ph.D. degree in Biological Oceanography.

Carol Reese in the shrimp laboratory.

A SNAIL'S PLACE

In the Center's laboratory for molluscan studies, **Dr. Nat Apter** and **Dr. Pat Blackwelder** are looking at a sibling snail species called *Littorina ziczac*-complex. Found on the shores of southeast Florida, the species complex is composed of 3 closely related snails (*L. ziczac*, *L. lineata*, and *L. lincolata)* that supposedly evolved together.

M.S. student **Peter Roopnarine** is working on a project that attempts to show a clear separation among the species. He has developed a mathematical formula for studying the curves that determine shell formations. In this manner he can detect and demonstrate variations of shell structures among species.

Dr. Blackwelder's experience with electron microscopy and her interest in biomineralization processes have encouraged the team to examine shell fine-structure and mineral composition for differences in the sibling species, from the earliest through successive phases of shell growth. The Scanning Electron Microscope (SEM) will allow, at regular intervals, evaluation of the status of calcium carbonate deposition in the organic matrix of the shell.

One interesting finding in the SEM studies shows that mineral formation starts just 24 hours after spawning, indicating that snails begin to form shells very, very early in the growth cycle.

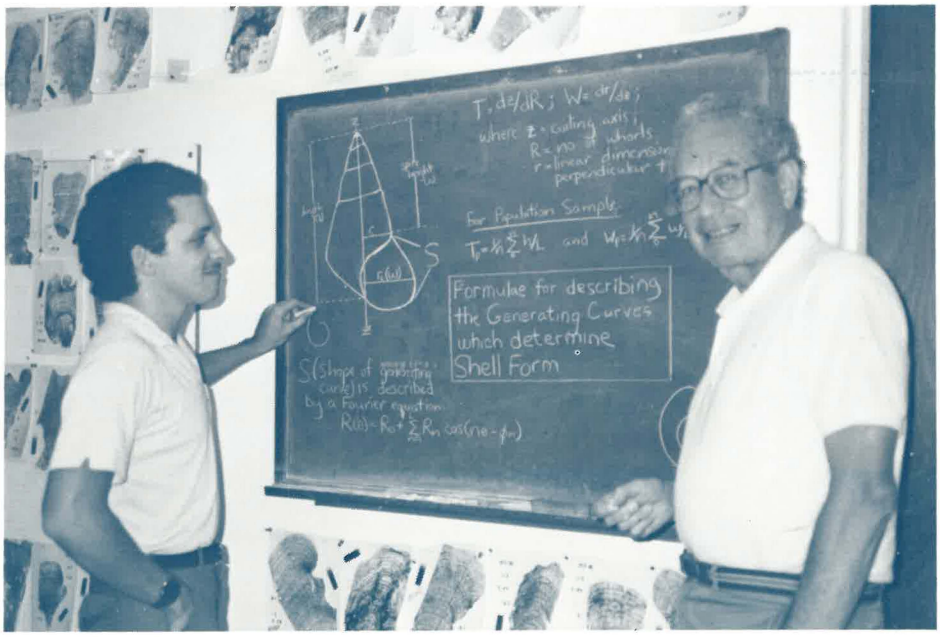
The group plans to look for differences among species in topographic arrangement and distribution, as well as in the timing, rate, quality and quantity of the secreted mineral. It is hoped that in this way patterns of early divergence in the morphological organization of the sibling species will be revealed. Because many molluscan researchers have not yet accepted the separation theory, Dr. Apter finds progress in this area particularly gratifying.

Dr. Pat Blackwelder with electron microscope.

After joining the center as a resident adjunct in 1983, Dr. Apter wasted no time in his quest for knowledge about his new molluscan acquaintances. He could frequently be spotted across the road by the jetty tide pools, collecting intertidal specimens in a bucket. His interest has been in not only the taxonomy of these snails, but also the relationships among the 3 species from an evolutionary standpoint. Which came first? An interesting problem has arisen, for example, in that one of the species is said to have evolved from a very distant source.

As Dr. Apter describes the transition to his new-found avocation, "In my other life, I was a behavioral scientist, a professor of psychiatry at the University of Chicago. I was interested in the comparative organization of the central nervous systems and their behavioral correlates." After moving south a few years ago, he continues, "I undertook to investigate developmental processes in less complex organisms. The shores of southeast Florida provided an ideal subject for study in the form of the *Littorina*, closely related but recognizably different morphologically."

Dr. Apter remains intrigued by snails. "Besides," he offers, "snails don't talk back, they don't phone at night, and you only have to deal with their relatives when you want to."



Peter Roopnarine diagrams snail shell configurations for Dr. Nat Apter.

FROM ZIG-ZAGS TO ZICZACS

The actual shell forms of the *Littorina ziczac*- complex are as intriguing as the name given to this species of snail. (Yes, the name did evolve from the word "zig-zag," which describes the general shell pigmentation.)

M.S. student **Peter Roopnarine** found the geometric characterization of these particular shell forms interesting enough to make it his thesis topic. Why are snails so appealing to study? His answer is that "many groups of snails are evolutionarily dynamic. They are very sensitive to the environment, and they reflect this in their shell morphology. So by studying these types of snails, you can learn a lot about evolutionary processes, which then apply to numerous other types of organisms."

Peter has developed mathematical formulae in order to detect and demonstrate variations in shell structures among species. In other words, he studies the curves that determine shell form.

Dr. Gary Kleppel opens the Friday seminar series.

He feels that just looking at a shell and describing it yields no information concerning its genetics or evolution. But the differences between shell types become more obvious when the shells are described mathematically. This factor is especially important to his attempt to differentiate among the 3 sibling species described in the preceding article.

One of the perks that has impressed Roopnarine during his study is that some of the snails that he has been looking at are from geographically remote populations. This means that often he has had the opportunity to go to St. Croix, for example, to collect samples. Most of the samples, however, have been collected within a few hundred yards of the Center. His subjects are found across the road at the jetty along the entrance to Port Everglades, along the Intracoastal Waterway at the inner Port jetty, and attached to the Center basin seawall itself.

Peter will be leaving us early in the year to work on his Ph.D. at the University of Maryland. He has been awarded a teaching assistantship there and will study molluscan evolution under **Dr. G. Vermeij**, in the Division of Evolutionary Zoology.

Peter Roopnarine points out unique shell patterns.

Friday Seminar Series Initiated

Last November, faculty, staff, and students were invited to participate in weekly seminars by their organizer, **Dr. Gary Kleppel.** In his words, "These seminars are specifically designed to be informal gatherings at which we can learn about what our colleagues are doing, exchange ideas, and obtain feedback on existing data or ideas for experiments, proposals and projects. They will be particularly useful opportunities for those preparing thesis or grant proposals, to present their ideas before protagonists, and for those preparing papers for meetings or journals to 'crystallize' their thoughts."

Five seminars have been presented so far: **Dr. Kleppel** on planktonic crustacea, **Peter Roopnarine** on environmental variables, **Carol Reese** on coral pigments, visiting professor **Stuart Godfrey** on heat budgets and ENSO, and **Dr. Russell Snyder** on surface gravity waves.

CURRENTS DOWN UNDER

Drs. Stuart Godfrey and Julian McCreary take a break.

For 6 weeks during November and December, the Center was pleased to play host to a visiting physical oceanographer from Down Under, **Dr. Stuart Godfrey**. His home base is CSIRO Marine Labs, located in Hobart, Tasmania (off the southeastern tip of Australia).

Dr. Godfrey and **Dr. Julian McCreary**, Center director, worked on various models of the Leeuwin Current, which runs along the west coast of Australia. Both scientists find the current of particular interest in that it is much more energetic than other eastern boundary currents in the subtropics, and because, remarkably, it flows directly *into the wind.*

Dr. McCreary worked up a simple model of this current several years ago, and he suggested that its anomalous characteristics were primarily due to temperature gradients offshore. Dr. Godfrey has developed a somewhat different model of the current. Last year the two had an opportunity to get together in Tasmania to discuss their models. They decided to work with a third, more sophisticated (eddy-resolving) model, which is now being run by Ph.D. student **Yasushi Fukamachi**. Results, Dr. Godfrey reports, are "encouraging."

Dr. McCreary plans to return the visit next summer (when it will be *cool* Down Under). The two scientists will then have a chance to compare their models with observational data that is being collected as part of the LUCIE Program (Leeuwin Current Interdisciplinary Experiment).

When asked about his most memorable moments while visiting our laboratory, Dr. Godfrey replied with a lilting "Oh it was sad when the great ship went down...." He was referring to that dark night in November when he awoke on a slant on the top floor of the center's guest houseboat. It was sinking, you see....

Ooops.

People On The Move

Dr. Pijush Kundu and **Dr. Georges Blaha** attended the annual meeting of the American Geophysical Union (AGU) in San Francisco, December 7-11. Dr. Kundu presented a paper entitled "Interaction of Internal Waves and Mean Flow." Dr. Blaha presented a poster entitled "Nonlinear Least-squares Adjustment."

The Oceanographic Center was well represented at the annual AGU Ocean Sciences meeting, held in New Orleans January 18-22. **Carol J. Reese**, M.S. student in Ocean Science, was in attendance. **Drs. Gary Hitchcock** and **Gary Kleppel** and Ph.D. student **Denis Frazel** presented a poster session with **Dr. Donald Olson** (RSMAS, University of Miami) entitled "The Use of an Isopycnal Float-Fluorometer during a Seasonal Study of the Somali Current." **Linda T. Smith**, Research Associate, presented a paper entitled "A Wind-driven Isopycnic Coordinate Model of the North and Equatorial Atlantic."

Drs. Richard Dodge and **Gary Kleppel** traveled to St. Croix, Virgin Islands, to attend a NOAA-sponsored coral workshop, December 9-10. Discussion focused on an unusual, global, reef coral bleaching event that began in the summer of 1987. They presented some preliminary data on pigmentation and growth of Broward County corals (more on this in the next issue of *Currents*).

Jan Witte, research associate, is coordinating and will attend the Symposium on Global Ocean Prediction Systems at GFDL, Princeton University, May 11-13. The symposium is being sponsored by the Institute for Naval Oceanography (INO), which is based in Bay St. Louis, Miss.

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Currents
NOVA UNIVERSITY
OCEANOGRAPHIC CENTER
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A November Visitor

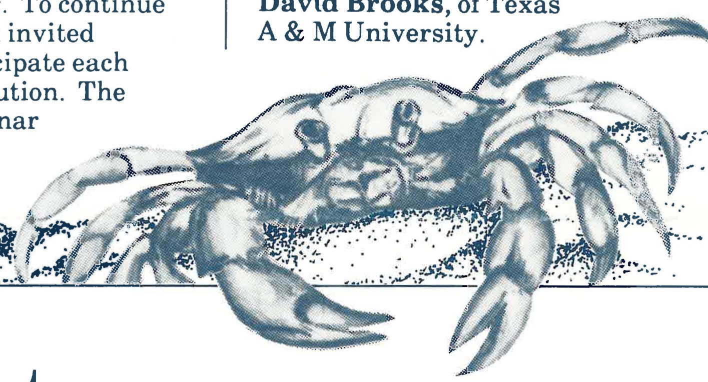
For four days during mid-November, **Dr. Evelyn Lessard**, from Horn Point Marine Lab (in Cambridge, Md.), ventured south to work with **Dr. Gary Kleppel**. Their project has to do with pigments of microzooplankton off Port Everglades.

Back to the Fold

Linda T. Smith, who began her stint at our lab as a computer programmer in early 1970, left us for a few years to tackle graduate work in physical oceanography at the University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS). Last July she successfully defended her M.S. thesis, entitled "A Wind-driven Isopycnic Coordinate Model of the North and Equatorial Atlantic." In October she returned to Nova to work (half-time) with **Dr. Russell Snyder** on a nonlinear gravity wave prediction model. Welcome home.

Richardson Seminar Series

The Oceanographic Center has joined RSMAS (University of Miami) and NOAA/AOML (Miami) in a revival of a joint seminar series, which has been named after the late **William S. Richardson**, our lab's founder and former director. To continue an old tradition, six invited speakers will participate each year, two per institution. The location of the seminar sites will be rotated among the institutions. The first seminar in the series was presented last fall at AOML by **Dr. Sidney Levitus**, of the Geophysical Fluid Dynamics Laboratory at Princeton. Nova will host the second seminar, which will be presented on March 4 by **Dr. David Brooks**, of Texas A & M University.



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